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**THE AFTEREFFECT OF INHIBITORY STIMULI****(EXTINCTION AND DIFFERENTIATION)**

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I. P. Pavlov ascribed high significance to the inhibitory processes occurring in the cerebral cortex. He gave particular attention to internal inhibition and its aftereffect. In his laboratories it was shown by many workers (Belyakov, Dekhtyarev, Ponomarev, etc) that the aftereffect lasts for entire minutes, and sometimes for tens of minutes, and applies to all the conditioned reflexes arising from a single analyzer.

Subsequently, the dependence of the aftereffect of inhibitory stimuli upon the type of nervous system was established by Usiyevich, Kryashev, etc). At present this question is being developed systematically by the personnel of the Physiology Faculty at the Cherkassk Pedagogical Institute under M. K. Bonyi.

I. P. Pavlov noted the existence of stimuli whose effects may be sustained for "entire days." It appeared of interest to determine how the aftereffect of a profound inhibitory process would proceed and whether it was possible, by inducing various types of internal inhibition, to produce differing effects upon conditioned-reflex activity.

**Method**

The study was conducted by means of 8 dogs with fistulas of the parotid salivary glands.

We classified the dogs by type of nervous system in accordance with the classic Pavlov method of conditioned reflexes.

The dog Medved' was a male mongrel, 23 kg in weight. He was highly excitable and aggressive. Positive and inhibitory conditioned reflexes were elaborated rapidly, but values could not be determined exactly, due to his extreme excitability he squirmed in his stand, jumped at the screen, tore away bulbs, chewed rubber tubes, pulled his legs free from straps, attempted to jump off the stand, and behaved quite aggressively.

Medved' could thus be classified as having the strong, impulsive type of nervous system.

The dog Trezor, male, 13 kg in weight, was of mixed German shepherd and mongrel ancestry. Positive to light conditioned reflexes were elaborated at the seventh combination of stimuli, and to a bell, at the fifth. They became fixed at the twentieth. Differentiation was established on the seventh repetition, but was of inadequate stability.

By type characteristics, Trezor was classifiable in the strong, unbalanced type of nervous system.

Sultan was a male mongrel, 22 kg in weight. Outside the laboratory he was aggressive, but within it he was quiet in a restrained manner, but not affectionate. Positive and inhibitory conditioned reflexes were elaborated rapidly, but were unstable, and often disappeared.

By type characteristics, Sultan was classified as in the moderately strong, unbalanced category of nervous system.

Drushok, a mongrel, was a male 26 kg in weight. He was affectionate and even-tempered. Both positive and inhibitory conditioned reflexes took a long time to elaborate, and were unstable over a 6-month period. By type, Drushok could be categorized as having the weak type of nervous system.

Tuzan, a mongrel, was a male 19 kg in weight. His positive conditioned reflexes developed slowly. Differentiation was unstable. By type characteristics, Tuzan could be characterized as falling into the extremely weak type of nervous system.

Experiments were run on these dogs daily, at the same time each day. The interval between application of stimuli varied, as we were unable to maintain a stereotype in the course of our work. After the elaboration of positive conditioned reflexes, and the establishment of differentiation, we proceeded to the basic experiments. We studied the effect of fading and intensified differential inhibition. The use of fading or intensified differential inhibition in the middle of an experiment did not produce clearly-defined results, and we decided to apply inhibitory stimuli only at the end of the experiment. In experiments with the extinction of the conditioned reflex, the stimulus was repeated at the end of the experiment every minute or two, and the effect was carried to 2 or 3 failures to respond, whereupon the experiment was brought to an end. During subsequent days, the aftereffect of this inhibition upon conditioned reflex activity was investigated.

A differentiating stimulus was applied 3 times at the end of the experiment, with one-minute intervals. On the days which followed, study was made of the aftereffect of intensified differentiating inhibition on conditioned reflex activity.

### The Research Proper

In experiments with ordinary extinction on the dog Medved', we found the conditioned reflex to a bell not to undergo extinction, the animal entering a state of marked excitation: whining, running around in circles, jumping at the screen, howling. The extinction experiment ended at the fifteenth repetition of the bell when Medved' tore away the bulb and tried to jump off the stand. After reinforcement of the bell, the experiment was continued, and finished in a wholly normal fashion.

Complete extinction of the conditioned reflex to gurgling was obtained on the ninth repetition, the experiment being carried to 3 failures to respond. The stimulus was repeated every 1.5 minute, without reinforcement.

In Table 1 we adduce the magnitude of the conditioned reflexes 2 days before extinction, on the day of extinction, and during the days which followed, until return to normal.

Table 1 shows that, subsequent to extinction, one could observe inhibition of the conditioned reflex to the extinguished stimulus for 4 days, the conditioned reflex returning to normal only on the fifth day.

[See Table 1, following page]

The conditioned reflex to the bell underwent no change, while that to light increased to 6.8. Differentiation was retained.

With Trezor, extinction of the conditioned reflex to the metronome, with repetition every 1.5 minutes, yielded 0.0 at the twelfth repetition. At the end of the experiment we used the metronome and reinforced it. Table 2 shows the after-effect of extinction.

TABLE 1 \*

## EFFECT OF EXTINCTION ON MAGNITUDE OF CONDITIONED REFLEXES

Date	Light	Dog Medved'		Differentiating light	Notes
		Bell	Gurgling		
1950					
17 March	3.2	8.3	9.6	0.0	
28 March	3.4	8.2	10.2	0.0	
29 March	2.8	5.5	<u>13.3</u> 0.0	0.0	Extinction of conditioned reflex to gurgling
30 March	4.6	8.5	0.7	0.0	(* In tables 1-3 the decimals indicate the degree of extinction of the conditioned reflex.)
31 March	6.5	8.2	2.1	0.0	
1 April	4.6	6.7	1.5	0.0	
3 April	5.2	7.2	9.0	0.0	
4 April	6.8	10.5	11.2	0.0	

Table 2 shows that the aftereffect of the inhibitory stimulus affected the extinguished reflex only during the first 2 days. On the third day the reflex underwent a marked strengthening, and on fourth, approached normal. As far as the differentiating stimulus is concerned, it lost its inhibitory effect which returned only on the twelfth day after extinction. It is to be noted that Trezor showed unstable powers of differentiation in general.

Voron showed complete extinction of the conditioned reflex to the bell (on repetition without reinforcement, every 1.5 minutes) on the fourth repetition, the experiment being carried to 3 consecutive failures to respond. Table 3 illustrates the aftereffect of extinction.

As shown in Table 3, the dog Voron showed a sharp decline in the conditioned reflex to the extinguished stimulus (to 0.8).

reduction in the conditioned reflex to clicking, and increase to 5.5 in the conditioned reflex to light. On the second day after extinction, the positive reflexes returned to normal, but differentiation was disinhibited. Differentiation was restored on the third day after extinction.

Thus, the results of the experiments performed show that with 3 animals having strong nervous systems, the inhibitory process applies, from the moment of extinction to the following days, chiefly to the reflex that had been subjected to extinction. It is interesting to note that the weak stimulus, light, was always elevated after an experiment in the extinction of another stimulus.

Let us now proceed to a description of the experiments with standard extinction in dogs having weak nervous systems.

The dog Tuman failed to respond to the seventh repetition of the ringing of a bell every 1.5 minutes, at the end of an experiment in extinction of the conditioned reflex thereto. Extinction was carried to 3 failures to respond, and the experiment was then cut off.

[See Tables 2, 3, and 4, following page]

Table 4 adduces the results of the aftereffects of extinction.

From Table 4 it is clear that after the usual extinction of the conditioned reflex to the bell, it was inhibited for the 6 days following, returning to normal only on the seventh. As far as other stimuli are concerned, the conditioned reflex to light (a weak stimulus) fluctuated, and failed to return to normal even on

TABLE 2

## EFFECT OF EXTINCTION ON MAGNITUDE OF CONDITIONED REFLEXES

Dog Tressor

Date	Light	Bell	Metronome	Electric hummer	Differenti- ating light	Notes
1948						
27 October	3.0	8.0	6.0	8.0	0.0	
28 October	3.0	6.7	7.0	8.0	0.0	
29 October	4.0	6.8	$\frac{7.6}{0.0}$	0.0	2.5	Extinction of condi- tioned re- flex to met- ronome
30 October	4.5	6.5	2.0	9.5	6.0	
1 November	4.8	6.2	4.5	9.5	3.2	
2 November	3.8	5.0	9.8	6.5	2.0	
3 November	3.5	3.0	6.3	7.5	6.0	

TABLE 3

## EFFECT OF EXTINCTION ON MAGNITUDE OF CONDITIONED REFLEXES

Dog Voron

Date	Light	Bell	Rattle	Differenti- ating light	Notes
1952					
29 September	1.5	4.5	3.5	0.0	
1 October	3.5	4.0	4.5	0.0	Extinction of conditioned
3 October	3.0	$\frac{4.2}{0.0}$	6.5	0.0	reflex to bell
4 October	5.5	0.8	2.0	0.0	
5 October	3.8	4.8	3.5	2.5	
6 October	2.2	4.7	3.5	0.0	



TABLE

## EFFECT OF EXTINCTION ON MAGNITUDE OF CONDITIONED REFLEXES

Dog Tuman					
Date	Light	Bell	Electric hammer	Differentiating light	Notes
1951					
8 September	4.5	3.2	6.5	0.0	Extinction of conditioned reflex to bell
10 September	4.2	5.5	6.2	0.0	
11 September	3.8	$\frac{6.0}{0.0}$	6.0	0.0	
12 September	2.5	1.5	4.0	5.0	
13 September	3.5	1.5	6.2	2.5	
14 September	3.5	2.0	5.8	1.5	
15 September	2.0	0.0	4.5	0.0	
17 September	4.2	3.0	4.2	0.0	
18 September	1.5	5.5	4.5	0.0	

the seventh day. The conditioned reflex to the electric hammer dropped to 4.0 on the first day after extinction, but returned to normal on the second. On subsequent days, the conditioned reflex continued to drop, and had not returned to normal on the seventh. On the next day, differentiation was disinhibited, and remained such for 3 days. Differentiation returned to normal on the fourth day after extinction.

With the dog Druzhok extinction of the conditioned reflex to the bell took place at the fifth repetition. Extinction was carried to 2 failures to respond, and the experiment brought to an end. Toward the end of the process of extinction, Druzhok's head drooped, and he began to drowse.

Table 5 illustrates the data on the aftereffect of the inhibitory stimulus.

Table 5 shows that the conditioned reflex to the extinguished strong stimulus -- the bell -- returned on the following day, but that it fluctuated sharply thereafter. The conditioned reflex to light was inhibited to zero on the first day after extinction and dropped by 50% in response to the electric hammer, while differentiation was disinhibited. During the next 7 days, the conditioned reflex to the extinguished stimulus fluctuated, but on the eighth it was elevated, and on the tenth it returned to normal. Conditioned reflexes to light and to the electric hammer fluctuate sharply at low levels. On the tenth day after extinction, the conditioned reflex to the electric hammer returned to normal, while the conditioned reflex to light had not by that day become normal.

The experimental data set forth led us to the following conclusions. In dogs having weak nervous systems the aftereffect is felt not only by the conditioned reflex of the extinguished stimulus, but by all other positive and negative conditioned reflexes.

In connection with the fact that we were interested in the course of the aftereffect of various inhibitory stimuli and as to whether, by inducing various types of internal inhibition, it was possible to call forth various effects on conditioned reflex activity, we conducted experiments involving more profound differential inhibition.

On 1 November 1949 the dog Trezor showed differentiation to light 3 times running at the end of the experiment, while the usual

procedure with that dog was to apply positive and negative light 3 times each in a day of experiments at various places. Table 6 shows the standard for positive and negative conditioned reflexes for 2 days, in which the data for positive and differentiating light represent averages for 3 conditioned reflexes for each day of experiments. On the third day differentiation was applied 3 times, and its aftereffect on the subsequent days is also shown.

TABLE 5

## EFFECT OF EXTINCTION ON THE MAGNITUDE OF CONDITIONED REFLEXES

Date	Light	Dog Drushok			Notes
		Bell	Electric hammer	Differenti- ating light	
1951					
16 September	1.5	5.3	3.5	0.0	
17 September	1.0	4.0	7.5	0.0	
18 September	1.5	5.5	4.5	0.0	
19 September	1.4	$\frac{5.5}{0.0}$	4.5	0.0	Extinction of conditioned re- flex to bell
20 September	0.0	5.5	2.2	0.3	
21 September	1.0	3.0	5.3	0.0	
22 September	0.0	5.0	0.0	0.0	
24 September	0.7	4.5	2.3	0.0	
25 September	2.0	0.0	0.0	0.0	
26 September	1.0	3.0	0.0	0.0	
27 September	0.0	7.0	0.0	0.0	
28 September	0.0	6.5	4.0	0.0	
29 September	2.5	5.5	4.5	0.0	

TABLE 6  
EFFECT OF THREE-FOLD DIFFERENTIATION ON THE MAGNITUDE OF  
CONDITIONED REFLEXES

Dog Trezor						
Date	Light	Bell	Metronome	Electric hammer	Differentiating light	Notes
1949						
29 October	3.3	4.8	6.2	6.4	0.0	
31 October	3.0	7.4	5.8	6.0	0.0	
1 November	3.2	7.0	5.8	7.5	0.0	Differ- entia- tion re- peated 3 times at end of ex- periment
	3.0				0.0	
	3.0				0.0	
2 November	3.5	10.0	12.0	8.7	2.7	
3 November	4.1	0.0	7.8	9.5	1.8	
4 November	7.1	14.0	6.5	6.5	2.8	
5 November	2.3	6.0	3.4	13.4	0.7	
9 November	5.5	7.5	4.5	5.5	2.0	
10 November	3.3	4.5	4.8	4.8	0.0	

Table 6 shows that on the day after the application of thrice-repeated differentiation at the end of the experiment, all the positive conditioned reflexes showed a marked rise, while differentiation was disinhibited. The following days showed a fluctuation of the conditioned reflexes. Differentiation was disinhibited for 8 days. On the ninth day the conditioned reflex to light approximated the normal. The conditioned reflexes to sound stimuli did not return to normal.

With Voron, differentiation to light was repeated 3 times at the end of the experiment on 30 October 1951. Table 7 shows the aftereffect of this intensified differentiation.

**TABLE 7**  
**EFFECT OF THREE-FOLD DIFFERENTIATION ON THE MAGNITUDE OF**  
**CONDITIONED REFLEXES**

CONDITIONED REFLEXES					Differentiating light	Notes
Date	Light	Dog Voron				
		Bell	Clicking			
1951						
26 October	2.5	3.5	4.0	0.0	Differentiation repeated 3 times at end of experiment	
29 October	2.0	2.5	2.0	0.0		
30 October	2.0	3.5	4.2	0.0 0.0		
31 October	3.5	3.0	8.5	0.0		
1 November	3.5	5.0	3.0	0.0		
2 November	3.0	5.0	3.5	0.0		
3 November	3.5	11.0	1.0	0.0		
5 November	2.8	6.0	2.5	0.0		

The table shows that on the day subsequent to thrice-repeated differentiation the conditioned positive reflexes to light and clicking showed an increase, while the bell reflex first remained at its normal level, but increased on the following days, and had not returned to normal after 6 days, differentiation not having been disinhibited. Subsequently, the conditioned reflex to light showed some elevation, and the magnitude of the conditioned reflex to clicking showed some fluctuation.

Differentiation was repeated 3 times with the dog Sultan at the end of the experiment of 29 October 1951. Table 8 shows the aftereffect of the intensified inhibitory stimulus.

As can be seen from Table 8, the positive conditioned reflexes showed an increase on the day after application of three-fold differentiation. Differentiation was disinhibited. On the following days the positive conditioned reflexes fluctuated, and on the eighth day they returned to normal. Differentiation returned to normal on the fifth day.

It is clear from the experimental data adduced that, in virtually all cases, application of thrice-repeated differentiation leads almost always to elevation of the positive conditioned reflexes on the following day, and to fluctuation in their magnitudes on subsequent days.

With the dog Voron, having the strong, balanced type of nervous system, these fluctuations were significantly less pronounced, and differentiation was not disinhibited (Table 7).

With the dog Trezor, having a strong, unbalanced type of nervous system, fluctuations in conditioned reflexes are particularly marked. Differentiation was disinhibited for a long period (Table 6).

Use of three-fold differentiation with the dog Sultan, having a moderately strong type of nervous system, produced fluctuations both in the positive and negative conditioned reflexes (Table 8).

The experimental data we have adduced show that:

(1) the development of strong extinctive or differentiating inhibition at the end of an experiment is reflected in the intensity of the conditioned reflexes for several days thereafter;

(3) extensive inhibition has different aftereffects with dogs having different types of nervous systems. With dogs of the weak type of nervous system, this aftereffect applies not only to the conditioned reflex undergoing extinction, but to all other positive and negative conditioned reflexes. With dogs having the strong type of nervous system, the aftereffect relates primarily to the extinguished conditioned reflex;

(3) intensified differential inhibition produces greater fluctuations in conditioned reflexes on successive days than does extinguishing differential inhibition. The marked fluctuations on recovery of the conditioned reflex apparently testify to the fact that internal inhibition, which is elaborated slowly, leaves an inhibitory effect for a long time;

(4) extinction, as a sudden conversion of a positive stimulus to a negative, rises smoothly and without sharp fluctuations during the period of restoration of the conditioned reflex.

TABLE 8  
EFFECT OF THREE-FOLD DIFFERENTIATION ON THE MAGNITUDE OF  
CONDITIONED REFLEXES

CONDITIONED REFLEXES					
Date	Light	Dog Sultan		Differ-	
[1]	[2]	Bell	Metronome	entiating	Notes
		[3]	[4]	light	[6]
				[5]	
1951					
22 October	3.0	8.0	6.7	0.0	
23 October	3.0	5.5	6.2	0.0	
28 October	2.8	6.2	6.3	0.0 0.0 0.0	Differentiation repeated 3 times at end of ex periment
25 October	4.5	6.5	8.5	2.4	

[1]	[2]	[3]	[4]	[5]	[6]
26 October	3.3	6.5	4.0	2.0	
29 October	3.8	8.4	8.2	1.0	
30 October	4.0	6.0	5.2	0.0	
31 October	3.5	6.0	6.5	0.0	